

RESTRICTED CIRCULATION

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Agricultural Memorandum No. 818

Combining Hours - A computer program for a simulation study

Introduction

The Program computes the time that a crop will take to dry after being wetted by rain, and totals those hours when the crop is dry and with a moisture content below a specified level. Such periods contribute to total combining hours.

The program will be able to be used to assess the yearly variation of available combining time, and the economic effect of changing input thresholds such as critical moisture content, or of combining during darkness. The overall structure of the program has been designed to be applicable to almost any outdoor process which involves sequential wetting and drying.

Physical Basis

This is identical to that described by C V Smith in Agricultural Memoranda Nos 393, 414. Basically, it is assumed that the rate at which moisture is removed from the surface of a crop follows the daily solar radiation input, and can be represented as a sinusoidal pulse. At dawn and dusk the pulse has zero amplitude, and if the potential transpiration for the day has been calculated independently, then the peak amplitude of the pulse can be deduced. The calculation of this amplitude is incorporated into the program in a subroutine TIMDRY.

The rate of loss of internal moisture follows an exponential rate during drying spells and is computed in another subroutine MOSDEC (Moisture decrease). Subroutine COMBIN totals the hours during which the crop is dry and below the critical internal moisture level. At present 'unsociable' hours have not been excluded.

## Change in assumptions

C V Smith made the simplifying assumption that all rainfall reported within a 24 hour period (09 - 09 GMT) falls not intermittently, but in one period of continuous rainfall. Differences in the structure of the present program do not require this assumption to be made. The determination of times of start and finish of rainfall is independent to this program, as it was in Smith's approach.

## Structure of the program

This differs from the earlier approach of Smith which considered a day falling into one of 7 basic cases I-VII, each subdivided into 4 sub divisions a, b, c, d. Sub divisions b and c of each case could each arise in 2 alternative ways.

Agricultural memorandum 414 described the means by which days were classified into each of the 28 cases. It is presumably because of the need for this classification that the assumption of one period of rain per day was necessary, as otherwise it would appear that an infinite number of cases would be required to describe all the possible combinations of rainfall start and finish times.

The approach adopted in the current program is different in that it only considers single pairs of events e.g. the period between sunrise and start of rain, finish of rain and time that the crop surface is dry, time of sunrise and sunset etc, and then calls upon the subroutines appropriate to the processes occurring during the interval between the events. The number of combining hours (if any) arising during the period is then added to the previous total before the next pair of events is considered.

At sunrise one of three states is possible:-

- A. It is not raining and the crop is dry.
- B. It is not raining but the crop is still wet from some previous rain (the presence of dew could be incorporated but has not been included yet; see section on future developments).
- C. It is raining and the crop is wet.

As an example suppose that state A applies. Because it is not raining the next event to occur is either sunset or the commencement of rain. The program determines whether there is a time of start of rainfall before sunset. If there is not the

program continues and calls MOSDEC and COMBIN, and if the internal moisture content is below the critical value, totals the hours between sunrise and sunset as suitable for combining. If however rain commences before sunset then the program only totals the hours between sunrise and the time of first rainfall before proceeding to the next event.

Figure 1 shows diagrammatically the full range of possibilities that can apply. Each state that can exist is designated by a letter, and there is always a choice of 2 possibilities to follow. The only exception is state B (crop wet, not raining) when there are 3 possible alternatives to follow i.e. (start of rain before crop dry), H (sunset before crop dry), and F (crop dry before sunset). Before the decision can be made as to which terminal state (B to D, B to H, or B to F) applies, subroutine TIMDRY is called. If TIMDRY decides that the crop will not be dry until after the commencement of rainfall then route BD is followed and no combining hours are added, and no moisture decrease occurs. Thus neither COMBIN nor MOSDEC are called.

In the program the state pairs are designated by the identifying letters of their terminal states e.g. Dry all day AG, Wet and raining all night IN.

This overall approach insures that each section of the program is in itself quite simple, and because there is no limit to the number of times a section can be traversed, there is no requirement to restrict the number of occasions on which rain occurs in a single day.

#### Present state of the Program and current developments

The program has been run successfully and tested by inserting input data which force all sections into operation. Before resorting to the generation of simulated start and finish times of rainfall using random number techniques (as suggested in Agricultural Memorandum 414) various other approaches should be investigated. These include access of computer stored data from which the rainfall times could be inferred, such as the coded 'present weather' observations. Autographic records might be available in some circumstances. A single random number approach would be not in itself present any programming difficulties, the main snags would be in attempting to insert realistic weightings concerning the differing probabilities of rain during the day or night, or in varying rainfall duration to correspond with differing synoptic situations. If such variations were ignored, there would be difficulty in knowing what degree of confidence to place on the overall result.

By running the program with real climatic data, it is already capable of being used to evaluate a number of inter-relationships. For example, the number of combining hours available in a given season will be increased if grain moisture levels at the time of cutting are allowed to rise. The consequence of this is an increased drying cost. The program can provide data which will assist in the economic assessment of such action.

### Future developments

Although the program can already be used in the manner described above, the addition of various subroutines (particularly to the data input facilities) will render its application to a variety of cases more attractive.

As the program stands times of sunrise and sunset have to be inserted as input data. Subroutines for calculating these exist so that provided a starting date is specified this requirement could be eliminated.

The use of a powerful computer removes the overriding need for ultra simple physical models. Thus the physical basis for subroutines MOSDEC and TIMDRY should be examined and could be replaced by more sophisticated models if this was found to be justified. For example, at present it is assumed that rainfall in excess of 0.5 mm is not retained by the crop surface. This is unlikely to be true in all circumstances, and it would be easy to test the sensitivity of the total combining hours result to small changes in this parameter.

At present daily values of potential transpiration are entered separately, as in the case of rainfall and time of sunrise and sunset. If the latter values can be derived using the computer data bank, the possibility exists of using this to derive daily transpiration values also. The possibility thus exists of compiling a program which only requires the specification of a starting date, Station number, and various flexible parameters such as critical moisture content. The economic effect of differing wage levels for 'unsociable hours', such as weekends or those before some specified starting time could therefore be very easily assessed.

At present there is an assumption that no drying can take place at night, and also there is no provision for moisture addition by dew deposition. This means that the program cannot at present be used to assess the economic significance of night time working, a practice which is not uncommon, especially in difficult seasons and upon which agrometeorologists are likely to be asked to comment. The provision of appropriate subroutines could overcome this shortcoming. In fact the structure of the program would be simplified since there would then be

no difference between the day and night networks.

### Conclusion

The program to compute combining hours from meteorological data provides a means of assessing the interaction of various parameters and their economic implications including some of a non-meteorological nature (e.g. identification of 'non sociable' hours). The sequential structure of the program allows for great flexibility and can be used to describe any drying and wetting process which follows a daily cycle. The subroutines which are called at appropriate stages in the program have, in the case described here, concerned the drying of a wetted crop. The structure of the program would remain totally unaltered if the subroutines concerned the drying process of (say) a damp road, or a wetted soil.

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### References

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Agric. Memo. No 414. Combining hours - the basis for a simulation study. Cambridge October 1971.

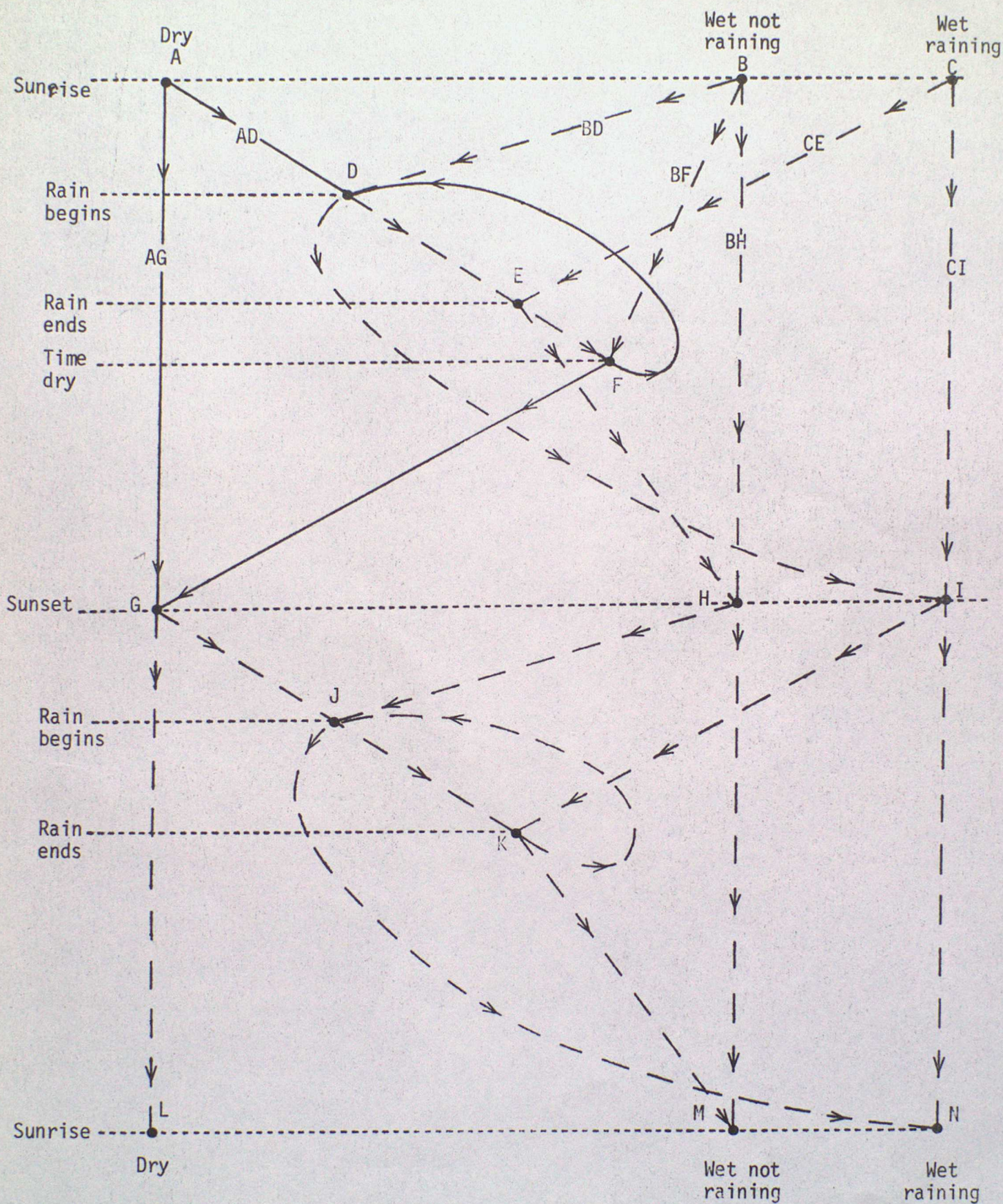


Figure 1. Diagram specifying the end states of each section of combining hours program. Solid lines indicate (daytime) hours when combining is possible.